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ABSTRACT

This study was designed to examine the effects of auditory memory, visual memory, and vocabulary knowledge on intramodal and intermodal delayed matching-to-sample tasks. A secondary objective was to assess the value of task performance and trait measures in predicting reading achievement. A total of 52 first graders were randomly selected as participants and their cognitive traits were measured individually with the visual-sequential memory subtest from the ITPA, the digit span subtest from the WISC-R, the picture vocabulary from the Stanford-Binet, and the vocabulary subtest of the WISC-R. Each child then participated in four delayed matching-to-sample tasks: (1) matching a visual stimulus with a previously seen visual stimulus, (2) matching an auditory stimulus with a previously heard auditory stimulus; (3) matching an auditory stimulus with a previously seen visual stimulus and (4) matching a visual stimulus with a previously heard auditory stimulus. The stimuli were ten pronounceable nonsense trigrams and response choices were formed from systematic alterations of these trigrams. A few weeks after the trait measures and matching-task data were collected, all first graders took the SRA as part of the district testing program. The data were analyzed with a series of multiple regressions and the results are presented and discussed in detail. (JMB)

# Trait-Task Interaction in Matching Visual and Auditory Stimuli

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The primary purpose of this study was to use a Trait-Task interaction approach to study the contribution of auditory memory, visual memory and vocabulary knowledge to variance in performance on each of four delayed matching-to-sample tasks. These tasks involved correctly matching verbal stimuli (CVCs) within and between auditory and visual modalities. A secondary objective of the study was to assess the value of task performance and trait measures in predicting reading level as measured by the Science Research Associates Achievement test (SRA).

Considerable information regarding word recognition cues chosen by beginning readers has been obtained through experimentation with the delayed recognition tasks used in this study (cf., Marchbanks & Levin, 1965; Swenson, 1975). However, explanations regarding the cues used and their relation to reading achievement are typically speculative due to limited data relating subject abilities to task performance and to reading achievement. Hence, in designing this study we asked ourselves: What cognitive abilities are necessary to correctly match CVCs in this delayed matching-to-standard task, and are there also data relating these particular abilities to beginning reading achievement?

In information processing terms, the child must first recognize and encode the standard trigram in some form and hold it in

short-term memory during the 10-second response interval. There is evidence, at least in regard to the adult's ability to recognize words, that recognition typically involves phonological recoding (LaBerge & Samuels, 1974). Phonological recoding of the stimulus could take place in a number of ways, and first graders would certainly be expected to differ in available language resources for labeling or recoding a stimulus. Hence, level of vocabulary knowledge was chosen as a means of measuring aspects of these language resources.

Short-term memory is another cognitive process that obviously interacts with encoding. Registration of the stimulus must be held in memory while the child considers the response choices for a correct match. Registration also seems to be increased to the degree that mediational units are engaged or elicited by the external stimulus. Although such mediational units need not be verbal, recent memory research indicates that initial encoding, even in preschool-age children, typically involves language (Hagen, Jongeward, & Kail, 1975). Thus, vocabulary knowledge and short-term memory seemed to be logical traits to study, and there was also data supporting their relation to reading achievement (cf., Fry, Johnson, & Muehl, 1970; Samuels & Anderson, 1973).

The inclusion of both auditory and visual CVCs also provided a means of assessing the relation of vocabulary and short-term memory to intermodal integration. Birch and Belmont (1964) and many others (cf., Freides, 1974) have studied auditory-visual integration in relation to reading achievement. Although evidence that intermodal integration is related to reading achievement

is still equivocal, it seems equally obvious that the typical beginning reader does recode information received visually into its auditory representation.

## Method

Subjects. From a population of first-grade children who had no vision or hearing loss, 52 were randomly selected. Chronological age ranged from 75 to 87 months with a mean age of 6.75 years. Age, sex, socioeconomic status (middle, low), and bilingual background (yes, no) were recorded for each child. A few weeks after the trait measures and matching-task data were collected, all first graders took the SRA as part of the district testing program. (The mean reading score of the 52 children was equivalent to a percentile rank of 45 on the SRA national norms.)

Traits. All 52 children were administered the visual-sequential memory subtest from the ITPA, the digit span subtest from the WISC-R, and both the picture vocabulary from the Stanford-Binet and the vocabulary subtest of the SISC-R. All children were tested individually. Tests were administered in counterbalanced order and all testing was completed before the matching-task data were collected.

Tasks and procedures. Each child participated in four delayed matching-to-sample tasks, two intramodal and two intermodal. The intramodal tasks were matching a visual stimulus with a previously seen visual stimulus (V-V) or matching an auditory stimulus with a previously heard auditory stimulus (A-A). The two intermodal tasks were matching an auditory stimulus with a previously seen visual stimulus (V-A) or matching a

visual stimulus with a previously heard auditory stimulus (A-V). Auditory stimuli were prerecorded on cassette tapes and visual stimuli were printed in primary type on index cards.

Stimuli were 10 pronounceable CVCs. To limit sound variation, CVCs were constructed from 10 consonants: five voiced and five unvoiced. Three vowels (a, o, u) were used. Each consonant was used in both the initial and final position, and both consonants in a CVC were either voiced or unvoiced. Vowels o and u were each used in three CVCs and a in four. Three additional practice CVCs were formed using j, l, and z with the same three vowels.

Response-choice CVCs were formed from systematic alterations of the stimulus trigrams. That is, response choices had the same initial consonant, the same final consonant, the same initial consonant and vowel, the same vowel and final consonant as the stimulus trigram or were a complete reversal of the stimulus trigram. On each trial, a stimulus item was presented with three response choices; two alterations of the stimulus and the stimulus item itself. In the 10 test items each alteration appeared four times in counterbalanced position and position of the correct match was also counterbalanced. The 10 test items were randomly ordered into 4 lists. ~~Assignment of list to~~ task was counterbalanced across ~~tasks~~ lists, and the order of [illegible] ~~presentation of~~ tasks was counterbalanced across children. The dependent measure for each task was the number of correct matches.

Results

A series of multiple regression procedures were used to examine the relations among the trait measures of vocabulary, memory, and task performance. In the first series, the two memory scores (auditory memory and visual-sequential memory) were combined in a total memory score. Total memory and vocabulary were the independent variables and the number of correct matches in each task was the dependent variable. Multiple Rs for the V-A, A-V, and A-A tasks were all significant ($p < .01$). In the A-V and A-A tasks, the memory scores made a significant contribution to the prediction of task performance. In the V-A task, the beta weight for vocabulary was significant ($p < .01$).

Because the beta weights for total memory were significant in the A-V and A-A analyses, the component memory scores were used with the vocabulary measure in stepwise regression analyses of the A-V and A-A tasks. The best single predictor of performance on the A-V task was visual-sequential memory, $R = .48$, $R^2 = .23$, $F\ (1, 50) = 15.23$, $p < .001$. The best single predictor of performance on the A-A task was auditory memory, $R = .37$, $R^2 = .14$, $F\ (1, 50) = 7.88$, $p < .01$. The tolerance for visual memory, if auditory memory was entered into the equation first, indicated that 93% of the variance in one memory variable was not accounted for by the other.

Analysis of the cross-modal tasks yielded different patterns of significance. Vocabulary was significant in the V-A task. Memory, specifically visual-sequential memory, was significant

in the A-V task. Therefore, two additional variables were created from the cross products of the standardized scores on the visual-sequential measure and vocabulary, and the auditory-memory measure and vocabulary. These cross product variables provided a means for studying the extent to which an interaction between level of vocabulary knowledge and level of the particular memory ability could account for task performance.

Three additional regression analyses were run. First, auditory memory, vocabulary and the cross product variable of auditory memory x vocabulary were used to predict V-A task performance. Auditory memory did not make a significant contribution $F$ (1, 50) = 3.37, $p < .07$ but, as before, vocabulary did contribute significantly $F$ (1, 49) = 10.34, $p < .002$. The cross product variable was entered next and did not make a significant contribution $F$ (1, 48) = .70, $p < .41$. Because the interaction of auditory memory and vocabulary did not contribute to explaining variance in V-A task performance, a second regression analysis was run with visual-sequential memory and the cross product of visual-sequential memory x vocabulary. Visual-sequential memory made a significant contribution $F$ (1, 50) = 5.00, $p < .03$. Vocabulary was entered next and, as expected, made a significant contribution $F$ (1, 49) = 12.23, $p < .001$. The cross product was entered next and accounted for an additional 11.64 percent of the variance, $F$ (1, 48) = 9.14, $p < .004$. The total multiple $R$ was .62, hence approximately 39 percent of the variance in V-A task performance was explained by the three

variables in the equation. The significance of the cross product was due to the more rapid rise of the vocabulary score than the visual-sequential memory score with improved task performance.

In the third analysis, visual-sequential memory, vocabulary and the cross product of the two were used to predict A-V task performance. As before visual-sequential memory made the significant contribution, $F$ (1, 50) = 15.23, $p < .0003$. However, without auditory memory in the analysis, when vocabulary was entered next, vocabulary accounted for an additional 8.9 percent of the variance, $F$ (1, 49) = 6.42, $p < .01$. The cross product variable added essentially nothing, $F$ (1, 48) = .06, $p < .81$.

Another series of multiple regression procedures were used to determine the relations among student classification variables, task performance, and reading achievement. Regression of tasks on the four classification variables (sex, SES, age, bilingualism) resulted in a significant multiple $R$ (.46) for the V-A task ($p < .01$). Only the beta weight (-.34) for bilingualism was significant, $F$ (1, 47) = 5.10, $p < .05$. Regression of SRA achievement subtests (reading, language arts and arithmetic) on the classification variables, yielded a significant result only for the reading subtest. Bilingualism again made the significant contribution to explaining variance, $F$ (1, 47) = 7.78, $p < .01$.

SRA reading scores were also regressed on tasks in a stepwise procedure to assess which task performance best predicted

reading achievement. V-A task performance accounted for the greatest amount of variance (15%) in the dependent variable, $R = .38$, $F(1, 50) = 8.59$, $p < .01$. No other task made a significant contribution to explaining variance in reading achievement.

Because vocabulary best predicted V-A performance, and both V-A performance and bilingual background accounted for significant variance in reading achievement, a final step-wise analysis was run to see which of these three variables would be the best predictor of reading performance. Vocabulary was selected on the first step and no other variable made a significant addition to the prediction of performance, $R = .39$, $R^2 = .15$, $F(1, 50) = 8.94$, $p < .01$.

Discussion

In contrasting the tasks correlated with memory (A-V and A-A) and the task correlated with vocabulary (V-A), a factor that obviously differs is the standard. Different results depending on the stimulus of first input is not a particularly unusual, nor a well explained finding in the cross-modal research (Freides, 1974).

V-V and V-A tasks. Due to a ceiling effect, little can be said about the relation of traits to V-V task performance. Consistent with the results obtained by Swenson and Fry (1975) who used the same stimuli with above average first-grade readers, performance on the V-V task was significantly better than performance on the V-A, A-V, and A-A tasks.

When the standard was visual and the response choices to match it were auditory (V-A task), vocabulary explained the most variance in performance. A cross product of visual memory x vocabulary also explained additional variance, not accounted for by either trait alone. Poor performers on the V-A task were below the mean on both the vocabulary and visual memory measures. Those who performed well on the V-A task (9 or 10 correct) were still generally not much above the mean in visual memory, but they were considerably above the mean on the vocabulary measure. The interaction indicated that as the children improved in V-A task performance, the difference between their vocabulary and visual memory scores increased.

Vocabulary knowledge could have no direct effect on recognizing the trigrams in this study because, though pronounceable, they were nonsense trigrams. One might speculate that vocabulary knowledge associates with knowledge of grapheme-phoneme correspondences, greater ability to verbally mediate one's response, or to make use of some type of subvocalized rehearsal. However, it is difficult to understand why such abilities would not have an equally facilitating effect on tasks with an auditory standard. When the stimulus is presented visually, level of vocabulary knowledge must associate with the type of encoding used. With a visual standard, the child at the low end of the vocabulary continuum may use orthographic encoding for retaining the representation of the standard. The number of reversal errors when the stimulus was visual seems to add

to the plausibility of this interpretation.

The V-A task was unique among the four tasks in the number of reversal errors that the children made. Typically, twice as many reversal (R) errors were made in the V-A task as in each of the other tasks (V-A = 51, V-V = 19, A-V = 26, A-A = 22). Swenson (1975) and Swenson and Fry (1975) also noted the disproportionate number of R choices in the V-A task. Freund and Johnson (1972) found orthographic encoding of single words presented visually to be more common than acoustic or semantic encoding with 6-year-old children. Hence, at this age, a visual standard may enhance the encoding of orthographic attributes. Perhaps when the letters rather than the pronounced trigram are held in memory, the letters get rearranged before the stimulus to match is presented. When the stimulus trigram is presented auditorily, an acoustic encoding is more likely held in memory and an R choice is not so likely to be made.

A-V and A-A tasks. In both the A-V and A-A tasks, where the stimulus standard was auditory and the trigrams to match it were visual, memory was a more important factor than vocabulary. The easiest encoding of the trigram in this task would seem to be to just repeat its pronunciation. If so, then those with the best short-term memory would do better on the task, particularly those children who repeated the auditory form and hence rehearsed the trigram while waiting for its visual representation. VandeVoort, Senf, and Benton (1972) also

concluded that problems with the A-V task were due to a deficiency in immediate memory or in encoding processes. However, these findings and conclusions are in conflict with Jorgenson and Hyde (1964) who found nonverbal A-V performance to be significantly correlated with reading vocabulary for the total sample of their children and especially for the second-grade boys. As in the present study, Jorgenson and Hyde (1974) found no overall relation between A-V performance and visual memory as measured by the ITPA, but visual memory was significantly related to the A-V performance of second-grade boys.

Within this sample of first-grade children, the measures of auditory memory (digit-span) and visual memory (ITPA) were essentially unrelated. This result is contrary to Jensen's (1971) conclusion, based primarily on college samples, that there is no significant individual difference in memory as a function of sense modality. Jensen hypothesized that both auditory and visual stimuli are encoded into a single auditory short-term memory system. The single-system interpretation is probably the present majority view. However, evidence that modality and memory are interrelated, particularly in children, is accumulating (Freides, 1974).

Few previous studies of intermodal integration, using nonverbal or verbal stimuli, included a V-A task as well as an A-V task. As Freides (1974) stated in his review, "The Birch-Belmont procedure, an auditory-visual sequence, was offered as an absolute measure of sensory integration, but there was no

reason given why the reverse sequence could not serve as well" (p. 287). The A-V task may predominate because it is easier to arrange for children to select a matching stimulus from a visual array than from an auditory one. The present study found that performance in the V-A task, and not the A-V task, best predicted reading achievement. Muehl and Kremenak (1966) using nonverbal stimuli and Swenson and Fry (1975) using verbal stimuli, found that both cross-modal tasks were significantly related to reading achievement. Since the evidence is limited, it would seem wise for future studies of intermodal integration in relation to reading achievement to include both a V-A and A-V task.

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